complementary to and bind the code. The detection element then detects the coded magnetic signal binding complex in the detection zone using electrical sensing methods, optical sensing methods, or enzymatic methods, such as amplifying the affinity agent (if it is a polynucleotide) on the magnetic signal affinity complex.

[0128] FIG. **9** illustrates an embodiment of the particle (or molecule) transport device of the invention, showing major components which are (1) a fluidic network, e.g., a biochip, (2) an electromagnetic array, (3) a circuitry board; and (4) computer. The fluidic network comprises a plurality of fluidic zones, each fluidic zone being connected to the adjacent zone by a diffusion barrier, and an integrated circuitry component, and optionally has a vibration element functionally coupled to the fluidic network. The array of magnetic microcoils functionally is coupled to the fluidic network, wherein the microcoils are programmably activatable to generate a magnetic field in proximity to each microcoil. The electromagnetic array can concentrate or transport magnetic particles, but dispersion of magnetic particles is preferably done by the vibrational device, which could be integrated in the fluidic network. A detection element (not shown in FIG. **9**) could be functionally coupled to the fluidic network.

[0129] The circuitry board shown in FIG. **9** contains the circuitry to control the elements (core/coil) of the electromagnetic array. The circuitry board is connected, either hardwired or by wireless connection, to a computer or any other device for controlling the switches of the circuitry board in a preferred sequence. The computer or any processing unit could include an embedded computer processor and/or could be capable of integrated computing.

[0130] Particle transport in the fluidic device is achieved by using the magnetic array and magnetic particles. Magnetic particles are commercially available. For clinical diagnostic applications, the particles could be conjugated with affinity binding partners (e.g. nucleic acid probes or antibodies); they could also be used together with other nanoparticles which can serve as either signal source or as carriers of signal sources. Magnetic particles and other reagents are placed in the fluidic device (e.g., biochip) containing multiple zones wherein liquid transport is not needed, and thus mechanism to generate fluid movement force is avoided.

[0131] To facilitate biomolecule detection, aggregated or concentrated particles in the fluidic zones may need to be dispersed, mixed, or resuspended in solution locally within in a fluidic zone. Dispersing can be achieved by mechanical means, e.g., the vibrational device such as ultrasounds (acoustic), piezo vibrations. The dispersing elements can be functionally coupled to the nBMA device (integrated with chip or the control device).

[0132] In one embodiment, the electromagnetic array comprises magnetic core, e.g., Fe cores, surrounded by power coils, preferably a set of planar coils. As shown in FIG. **10**, the cross sectional areas of the core of the electromagnet could have various geometries such as a star (FIG. **10**, bottom left) or a circle (FIG. **10**, bottom right). Generally, cores having the star cross-section produce a more even magnetic filed between two adjacent cores while cores having the circular shape produce a concentrated magnetic field in the region where two adjacent cores are closest. Thus, by appropriate choice of the cross-sectional areas of the cores, the electromagnetic array could have regions with substantially uniform or concentrated magnetic field.

[0133] The electromagnetic array creates magnetic field gradients that are sufficient to transport the magnetic particles in the fluidic device. The power coils can be switched by the switching circuitry, which in turn can be controlled by a computer. The switching could be on/off, high/low and/or at a desired frequency, which can be determined as a function of the time necessary for a magnetic particle to be transported within the fluidic device.

[0134] FIGS. **11**A and B show an embodiment of the switching circuitry. The computer generates low current signals which are used to control the high current needed for the electromagnets. The current for each coil can be controlled by either a solid state or electromechanical relay or current amplifier which is driven by a logical or analog signal generated by the computer control. FIG. **11**A is an example of a circuit for an individual magnetic element for which the polarity can be switched. So one would need two switches per element of the magnetic array. However, by the switching circuitry of FIG. **11**B, it would be possible to minimize the number of switches but keep the polarity fixed such that, for example, for N elements containing N coils, one would need just 25+N/5 switches.

[0135] FIG. **12** illustrates an example of the movement of magnetic particles on a microscope slide. Initially, in FIG. **12** (**1**), a liquid solution containing colored magnetic particles was spread out on a portion of the slide overlaying directly above three core/coil elements. Note that the microscope slide in FIG. **12** has been moved down to take the picture, but in the experiment, the liquid solution was on top of the three core/coil elements. Next, all three elements were switched on to have north (N) polarity. As a result, as illustrated in FIG. **12** (**2**), the magnetic particles in the liquid solution separated into two distinct regions above the first and third core/coil elements. Next, the three elements were switched on to have south (S), N, N polarity. In this case, as illustrated in FIG. **12** (**3**), the majority of the magnetic particles moved to a spot between S and N polarity elements and some magnetic particles formed a spot above the third element having N polarity. Next, the three elements were switched to have zero (no), S, N polarity. In this case, as illustrated in FIG. **12** (**4**), the magnetic particles moved to a spot between the second and third elements having S and N polarity. Finally, the three elements were switched on to have zero, zero and N polarity. In this case, as illustrated in FIG. **12** (**5**), the magnetic particles moved to a spot above the third element having N polarity. This example clearly demonstrates that a magnetic array within the embodiments of the invention can transport and/or concentrate magnetic particles within a fluid without any external fluid transport mechanism that generates hydraulic pressure for fluid transport.

[0136] FIG. **13** shows a prototype system for transport of magnetic particles, the system comprising coil (inductor) array, switches and other electronic control elements, together with a prototype fluidic device (e.g., biochip). The prototype system of FIG. **13** was used to demonstrate transport of magnetic particles in the biochip, illustrated in FIG. **6**. FIGS. **6** and **12** illustrate that the transport and/or concentration of magnetic particles demonstrated in FIG. **9** for a three coil array is scalable for any number coils.

[0137] FIG. **14** shows the specification for an embodiment of the prototype system of FIG. **13**, indicating the magnetic coil structure and magnetic field strengths relative to the coil head surface. As one would recognize, the magnetic field